MAIN ACCELERATOR LATTICE

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As a starting point the basic lattice type and parameters chosen for the main accelerator are:

1. Separate-function FODO lattice with matched long straights.

2. Ring radius R = 1000 m.

3. Bending magnetic field = 18 kG   at 400 BeV (or about 9 kG   at 200 BeV).

The various reasonings and considerations leading to the choice of the detailed lattice parameters are as follows:

1. Considerations of site layout and various straight section requirements led to the choice of 6 superperiods with 6 matched long straights.

2. For extraction the long straight drift space should be $>$ 50 m.

3. For injection and other purposes it is deserable to have in addition a medium straight per superperiod which can be formed by just leaving the bending magnets out of a half cell of the FODO lattice.

4. Considerations of the geometry and the equipment for injection and extraction indicate that the medium straight should be upstream from the long straight with a separation of about 150 m.

5. Aperture considerations led to a desired $\beta_{av} = \frac{R}{\nu} \approx 50$ m which gives $\nu \approx 20$.

6. For FODO lattice optimum β_{max} corresponds to about 5 cells per oscillation. When adjusted to a multiple of 6 (number of superperiod) the total number of cells for the ring was chosen to be 96, counting both the medium straight

and the long straight as half a cell.

7. The field gradient in the quadrupoles at 400 BeV should be as high as can be obtained with reasonable effort and acceptable quality to minimize the lengths of the quadrupoles.
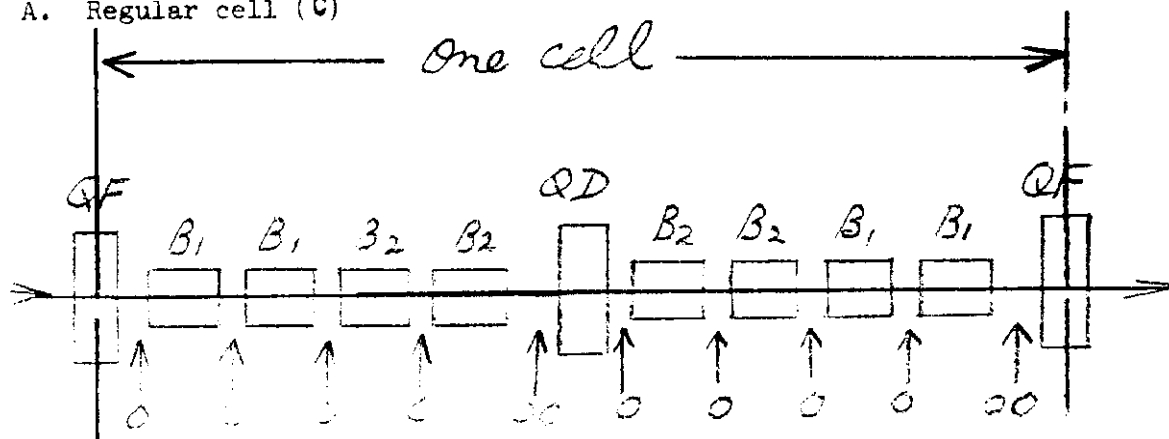
8. For ease of fabrication, handling, and support each bending magnet should be about 6 m (20 ft.) long.

The lattice and orbit parameters developed using the SYNCH program and based on the above reasonings and consideration are given below.

Physical Dimensions

(For engineering purposes these dimensions are given to more decimal places than significant figures.)

A. Regular cell (C)

Length of cell quadrupole QF and QD

$$l_Q = 1.68990 \text{ m} \qquad \text{(see Note 1)}$$

Length of cell bending magnet B_1 and B_2

$$l_B = 6.27465 \text{ m}$$

Length of minimum gap between magnets (o)

$$l_o = 0.30480 \text{ m}$$

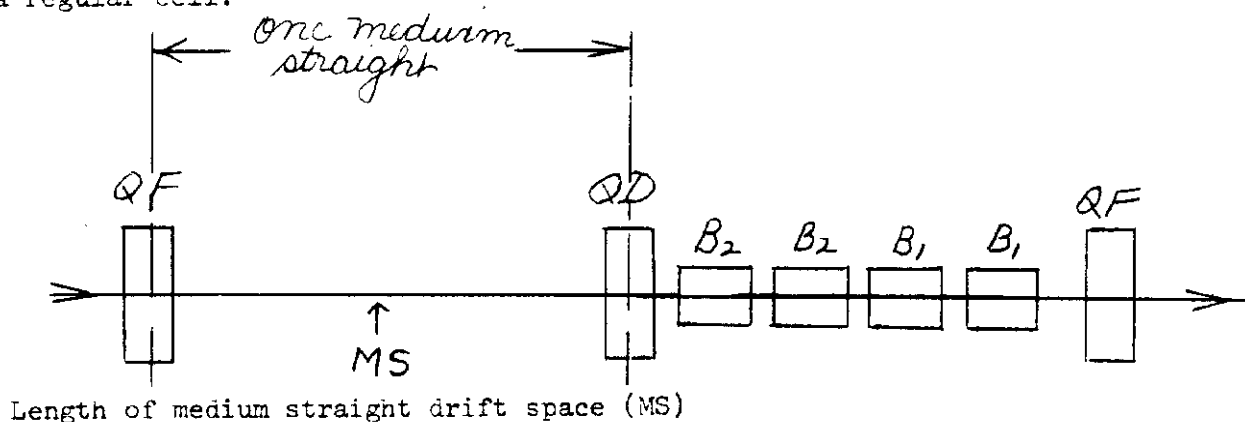Length of short (mini-) straight (oo)

$$l_{oo} = 2.44635 \text{ m} \qquad \text{(see Note 1)}$$

Total length of regular cell

$$l_C = 60.90810 \text{ m}$$

B. Medium straight (M)

This is formed simply by leaving out the 4 bending magnets in the first half of a regular cell.
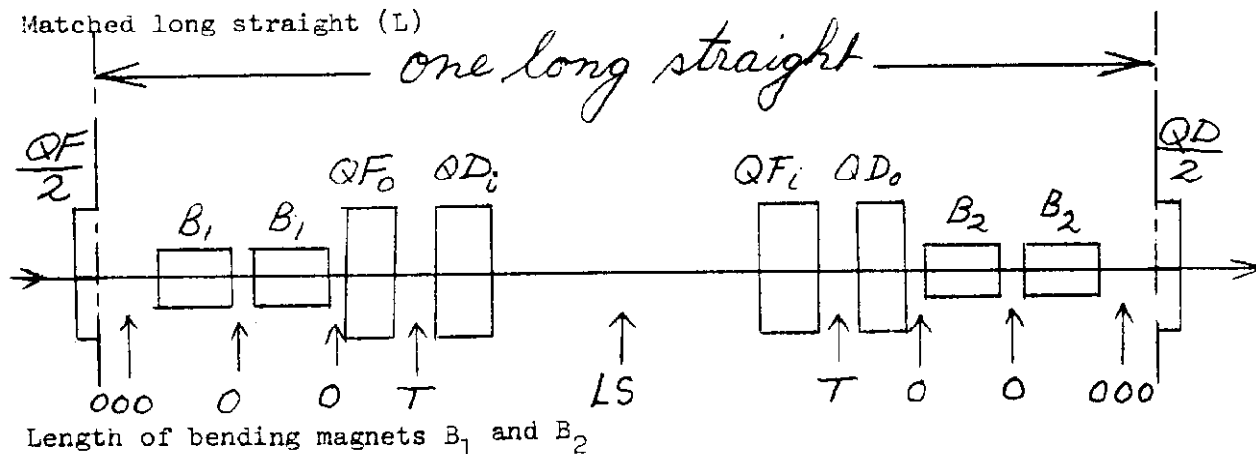

Length of medium straight drift space (MS)

$$l_{MS} = 28.76415 \text{ m}$$

Total length of medium straight = half length of regular cell

$$l_M = \frac{1}{2} l_C = 30.45405 \text{ m}$$

C. Matched long straight (L)

Length of bending magnets B_1 and B_2

$$l_B = 6.27465 \text{ m}$$

Length of outer matching quadrupoles QF_0 and QD_0

$$l_{Q_0} = 3.00000 \text{ m} \qquad \text{(see Note 2)}$$

Length of inner matching quadrupoles QF_i and QD_i

$$l_{Q_i} = 3.46860 \text{ m} \qquad \text{(see Note 2)}$$

Length of minimum gap between magnets (o)

$$l_o = 0.30480 \text{ m}$$

Length of straights at either end (ooo)

$$l_{ooo} = 3.04800 \text{ m}$$

Length of gap between inner and outer matching quadrupoles (T)

$$l_T = 1.81815 \text{ m} \qquad \text{(see Note 2)}$$

Length of long straight drift space (LS)

$$l_{LS} = 54.13470 \text{ m} \qquad \text{(see Note 2)}$$

Total length of long straight

$$l_L = 103.12200 \text{ m}$$

D. Superperiod (S)

Denoting a regular cell by (C), a medium straight by (M) and a long straight by (L), we can, then, write the superperiod as

$$(C)(C)(C)(C)(C)(C)(M\tfrac{C}{2})(C)(C)(L\tfrac{C}{2})(C)(C)(C)(C)(C)(C)$$

The total length of superperiod is

$$l_S = 1047.197550 \text{ m} = \frac{\pi}{3} R$$

Magnetic Field Parameters (at 400 BeV)

Field in cell bending magnets B_1 and B_2

$$\approx 18 \text{ kG}$$

Field gradient in cell quadrupoles QF and QD

$$= 306.7 \text{ kG/m} \qquad \text{(see Note 1)}$$

Field gradient in long straight matching quadrupoles QF_o, QF_i, QD_o, $QD_i =$
288.0 kG /m   (see Note 2)

Orbit Parameters   (see Notes 1 and 2)

A. Orbit radius in bending magnets

$$\int = 742.99 \text{ m}$$

B. Betatron oscillation phase advance

	Radial	Vertical
per cell Ψ_C	$0.19656 \times 2\pi$ $\approx 70.76°$	$0.19698 \times 2\pi$ $= 70.91°$
per med. st. Ψ_M	$0.09841 \times 2\pi$ $= 35.43°$	$0.09842 \times 2\pi$ $= 35.43°$

per long st. Ψ_L	$0.32765 \times 2\pi$ $= 117.95°$	$0.32781 \times 2\pi$ $= 118.01°$
per superperiod Ψ_S	$3.37446 \times 2\pi$ $= 1214.8°$	$3.38093 \times 2\pi$ $= 1217.1°$
wave number ν	20.247	20.286

C. Betatron oscillation amplitude functions βx (radial) and βy (vertical)

and momenum excursion $X_p \equiv \Delta x / \frac{\Delta p}{p}$

location	βx (m)	βy (m)	$X_p \equiv \Delta x / \frac{\Delta p}{p}$ (m)
Regular cell			
QF	101.3	27.7	
B_1	98.5	50.8	
B_2	56.2	90.3	
QD	27.8	101.1	
Long straight			
B_1	103.6	30.7	2.311
QF_o	103.7	48.9	2.320
QD_i	66.2	75.9	1.958
QF_i	76.0	66.3	2.651
QD_o	49.0	103.8	2.049
B_2	36.6	103.7	1.690
			6.843 (max.)
Average	49.39	49.30	2.659

D. Transition kinetic energy

$$T_{tr} = 17.257 \text{ BeV} \quad (\gamma_{tr} = 19.39)$$

Note 1

It may be difficult to obtain a field gradient of 306.7 kGa/m. within

acceptable tolerance for the cell quadrupoles QF and QD and we may have to reduce

this number. If so, the length of these quadrupoles will have to be increased.

But we can always reduce the length of the short (mini-) straights correspondingly to keep the total length of a regular cell unchanged.

Note 2

It may be advantageous to run the matching quadrupoles QF_o, QF_i, QD_o, and QD_i in the long straights at the same field gradient as the cell quadrupoles. In this case the lengths of these quadrupoles will have to be adjusted. Here, again, we can always readjust the length of the long straight drift space (l_{LS}) and the length of the gaps between the inner and outer matching quadrupoles (l_T) to keep the total length of the long straight unchanged.